Final Technical Report

COASTAL SCENE DESCRIPTION IN THE MIDDLE ATLANTIC BIGHT: DATA ANALYSIS, FEATURE MODELS AND DATA FUSION

ONR Grant N00014-94-1-G915

1 September, 1994 - 25 April, 1996

by

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This Final Technical Report covers the research and work carried out from October 1994 to April 1996. The work here described formed part of the Coastal (Tactical) Oceanographic Program in coordination and collaboration with Rutgers University (Dr. Scott Glenn), JHU/APL (Drs. Lee Dantzler and David Scheer) and APL/UW (Dr. Robert Miyamoto).

The work focused on i) scientific and technical issues related to the construction of environmental fields useful for coastal scene description via fusion of data streams and models; ii) demonstration of the approach in a real time nowcast-forecast exercise (Harvard/Saclant) in the Straits of Sicily (AIS94); and, iii) application of the methodology to the Mid-Atlantic Bight shelf and shelf-slope region.

The publications partially or fully supported under this project are listed in the Project Bibliography section below. A regional coastal scene description requires the establishment of a robust forecast system in the region. A general approach to the development of such a forecast system, with specific and concrete examples and experiences drawn from real time exercises, was reported in Robinson et al. (1996a). A systems approach to the general multi-disciplinary ocean nowcast-forecast-hindcast problem was reported in Lozano et al. (1996). These papers present practical methods to fuse relevant and available data sets and model outputs to construct dynamically consistent four-dimensional fields in an arbitrary operational region of interest.

Multi-scale feature models for the Gulf Stream,Meander and Ring region include feature models for the meander and rings melded with feature models for the re-circulation gyres and deep western boundary current. A kinematically and dynamically consistent procedure to meld data and feature models in this region is described in Gangopadhyay et al., (1996a). The calibration and validation of this multi-scale feature model is documented in Robinson et al., (1996b). The forecasting capability of the multi-scale feature model approach was demonstrated in Gangopadhyay et al., (1996) using the OTIS data set.

The multi-scale feature model referred to above is based upon the construction of an initial guess of the velocity field. An alternate approach is to construct multi-scale feature models based upon the temperature and salinity fields (Lozano et al., 1996). The latter approach is quite suitable for coastal regions. The combination of these two approaches was illustrated in Lozano et al., (1996) with a multi-scale feature model for the Middle Atlantic Bight-Gulf Stream Region. The simulations in the shelf region shown in

Middle Atlantic Bight-Gulf Stream Region. The simulations in the shelf region shown in Figure 1 were constructed (Sloan, 1996) by melding data streams (historical data, in situ MARMAP data, IR imagery), multi-scale feature models and a dynamical (primitive equation) model.

A practical demonstration for the rapid construction of four-dimensional fields in a complex region including shallow, deep and steep topography was achieved in a joined (HARVARD/SACLANT) cruise in the Straits of Sicily and Western Ionian during November, 1994 aboard the R/V ALLIANCE. This cruise constituted the initial exploratory phase necessary to establish a forecasting system for the region (Robinson et al. 1996a). During the cruise, aboard ship nowcasts and forecasts were prepared and updated daily using in situ observations, atmospheric forcing estimates derived from FNOC atmospheric analyses and forecasts. The observations were assimilated into a primitive equation model using an optimal interpolation scheme. The impact of observations was increased by using nested domains with increased resolution commensurated with data coverage. The data streams were assimilated in a large domain encompassing the Straits of Sicily and the Western Ionian, and in embedded domains. Figures 2 and 3 are reproductions of actual forecasts issued at sea for the nested domains in the Sicily Straits and Maltese Front, respectively. The sub-mesoscale resolution sampling in the Maltese front is matched with the grid resolution in this nested domain. The cruise revealed the Atlantic-Ionian Stream jets, filaments and eddies, the deep LIW flow, Maltese front region complex sub-mesoscale, wind driven Coastal Sicilian current, downwelling/upwelling events, and a complex mixing of multiple water masses (Warnas et al., 1996).

Project Bibliography **Grant N00014-94-1-G915**

1. Gangopadhyay, A., A. R. Robinson, and H. G. Arango. 1996: Circulation and Dynamics of the Western North Atlantic, I: Multi-Scale Feature Models. *Journal of Atmospheric and Oceanic Technology.* In press.

2. Gangopadhyay, A., and A. R. Robinson, 1996: Circulation and Dynamics of the Western North Atlantic, III: Forecasting the Meanders and Rings. *Journal of Atmospheric and Oceanic Technology.* In press.

3. Lozano, C. J., A. R. Robinson, H. G. Arango, A. Gangopadhyay, N. Q. Sloan, P. J. Haley, and W. G. Leslie, 1996: An Interdisciplinary Ocean Prediction System: Assimilation Strategies and Structured Data Models, *Modern Approaches to Data Assimilation in Ocean Modeling* (P. Malanotte-Rizzoli, editor), Elsevier Oceanography Series, Elsevier Science, The Netherlands, 413-452.

4. Robinson, A. R., H. G. Arango, A. Warn-Varnas, W. G. Leslie, A. J. Miller, P. J. Haley, and C. J. Lozano, 1996a: Real-Time Regional Forecasting, *Modern Approaches to Data Assimilation in Ocean Modeling* (P. Malanotte-Rizzoli, editor), Elsevier Oceanography Series, Elsevier Science, The Netherlands, 377-410.

5. Robinson, A. R. and A. Gangopadhyay, 1996b: Circulation and Dynamics of the Western North Atlantic, II: Dynamics of Meanders and Rings, *Jounal of Atmospheric and Oceanic Technology.* In press.

6. Warn-Varnas, A., A. R. Robinson, and W. G. Leslie. Water Masses of the Sicily Straits and the Western Ionian. In preparation.

References

1. Sloan, N. Q. (1996) Dynamics of a Shelf-Slope Front: Process Studies and Data Driven Simulations in the Middle Atlantic Bight, Harvard University, Cambridge, MA (Ph.D. Thesis).

FIGURE 6: REGIONAL SHELF/DEEP OCEAN DYNAMICAL SIMULATIONS

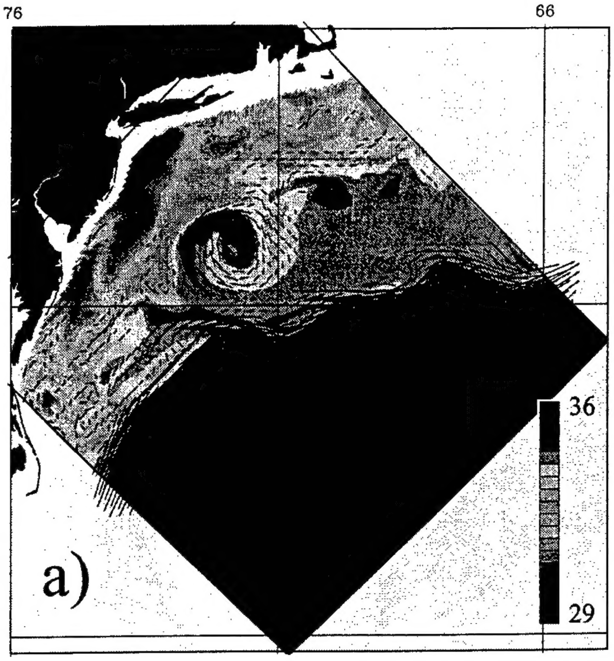


Figure a): Salinity at 1m from day 15 of a data-driven simulation of the Northwest Atlantic from the Middle Atlantic Bight continental shelf to beyond the Gulf Stream. A streamer of shelf water is extracted by a warm core ring; shelfbreak eddies exchange shelf and slope water; shelf water is entrained into the Gulf Stream near Cape Hatteras. Data-streams for initialization and assimilation include MARMAP/NMFS shelf hydrography, satellite sea-surface temperature, and feature models for the Gulf Stream, Warm Core Ring, and Shelfbreak Front.

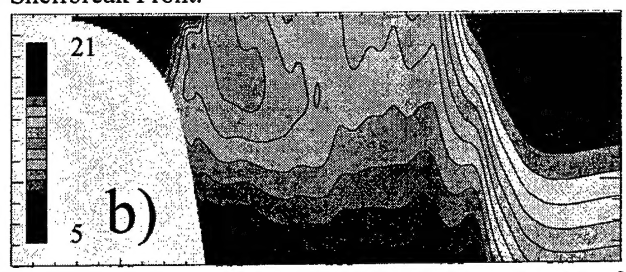


Figure b): Cross section of temperature at day 15 of the same simulation as a). From left to right, the cross-section shows the shelfbreak front, the leading edge of a Warm Core Ring, and the Gulf Stream.

Figures c) and d): Near surface temperature from a nested-grid, data-driven simulation of shelfbreak eddies and ring interactions. The coarse grid (c) is 7.5km, while the fine grid (d) is 2.5km. Data-streams for initialization and assimilation into the model include MARMAP/NMFS hydrography, a feature model Warm Core Ring and a feature model for the shelfbreak front. Events include shelfbreak eddies, in which shelf water is drawn off the shelfbreak and slope water is pushed up onto the shelf; and a shelf streamer interacting with a warm core ring.

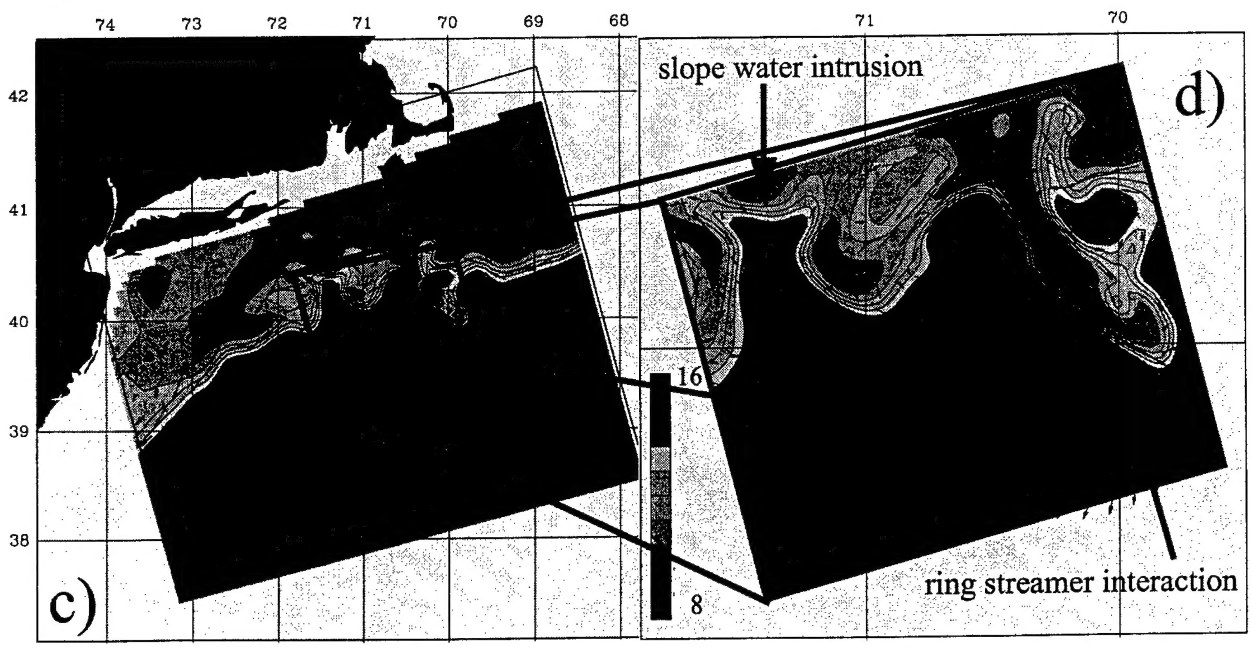


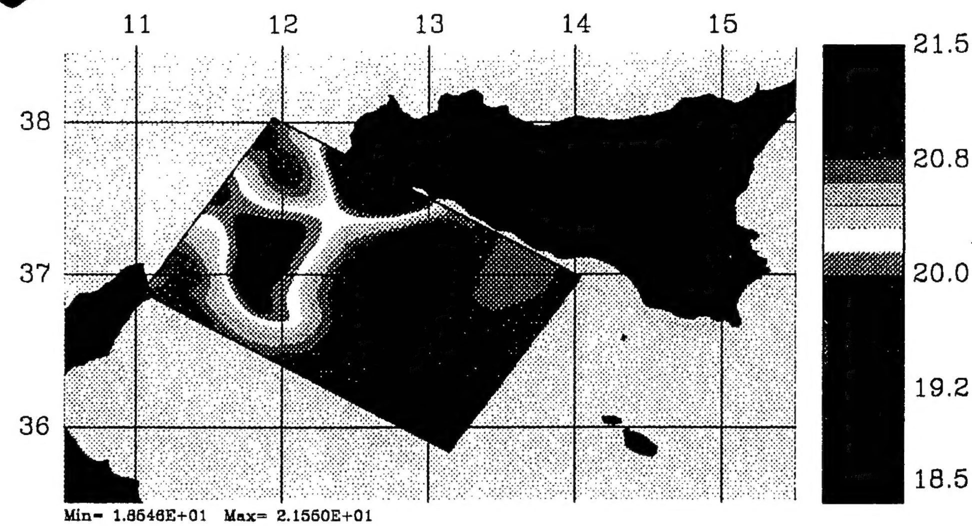
FIGURE 1

HARVARD / SACLANT

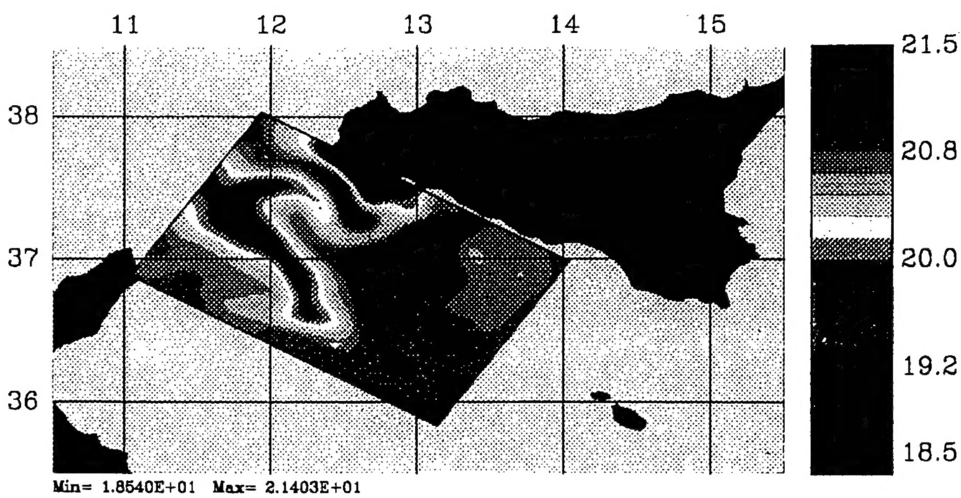
AIS94 R/V Alliance Nowcast/Forecast Simulation (RONF1C)

Climatology plus Tracks 1−3

Temperature at Level 1



Nowcast : 13 Nov 1994



4.00 Day Forecast : 17 Nov 1994

HGA
ARR
Nov 18, 1994

FIGURE 2

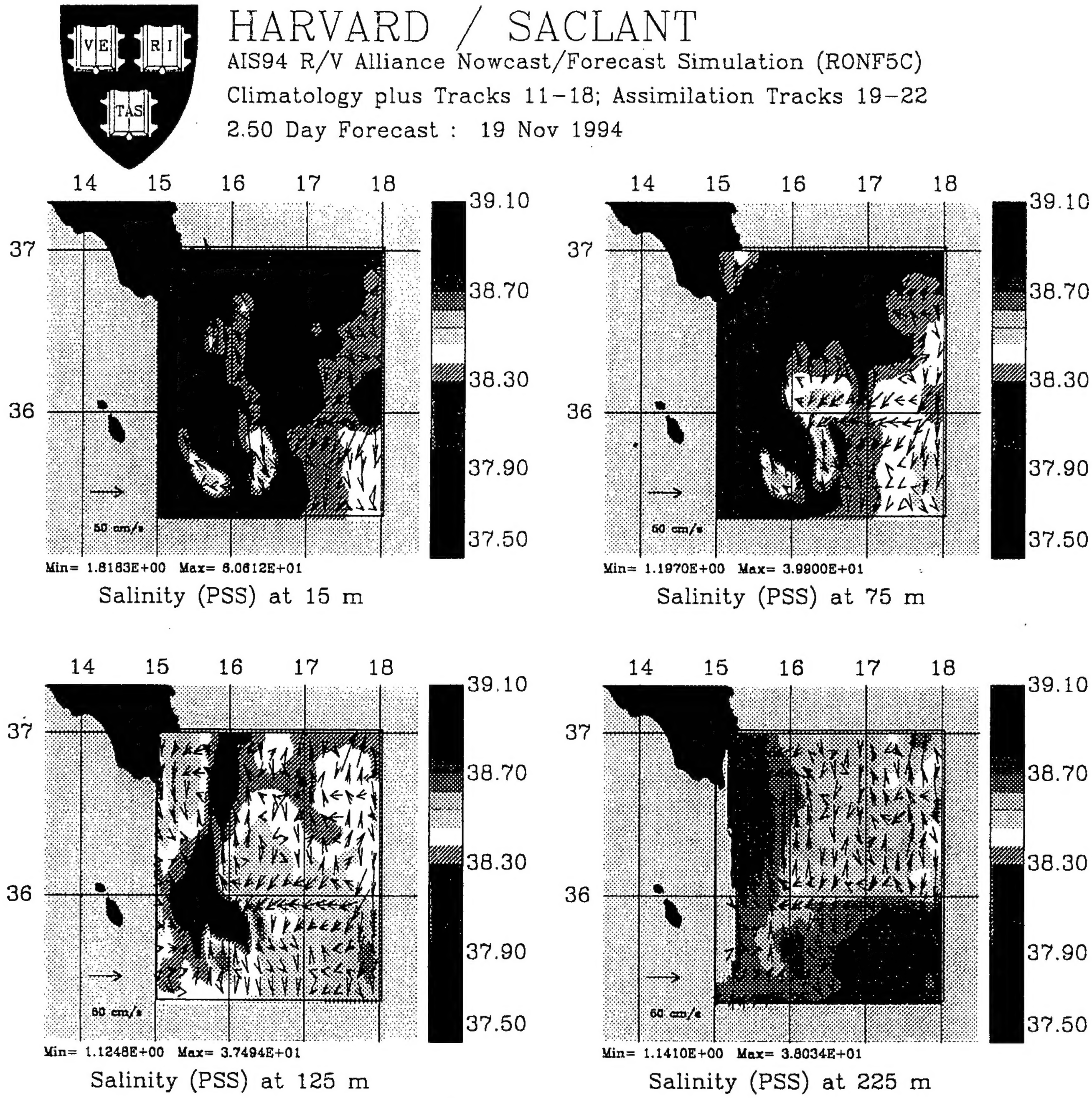


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FIGURE 3

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